EFFECT OF LEAF SHAPE ON FOREST LITTER COLLEMBOLA: COMMUNITY ORGANIZATION AND MICROHABITAT SELECTION OF TWO SPECIES

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ABSTRACT

Effects of leaf shape and leaf type on springtail community organization and on microhabitat selection of *Lepidocyrtus curvicollis* Bourlet and *Sminthurinus elegans* (Fitch) were studied in deciduous forest litter in central New York. Three litter boxes in each of four treatments (curled maple leaves, flat maple leaves, curled filter paper disks, and flat filter paper disks) were sampled monthly from November 1979 to August 1980. Collembola were extracted in Tullgren funnels.

Greater Collembola species richness and density of *L. curvicollis* occurred in curled litter than in flat litter. Greater amounts of interstitial space in curled litter account for these differences. No leaf shape effect was found for *S. elegans* density. This species was able to exploit all litter treatments because of its small size.

Fewer springtail species and smaller populations of *L. curvicollis* and *S. elegans* colonized filter paper disks in contrast to maple leaves. Reduced food resources (fungi) on filter paper disks account for this pattern.

Key Words: Habitat structure, *Lepidocyrtus curvicollis, Sminthurinus elegans*, species richness

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INTRODUCTION

For two decades, ecologists have been concerned with the relationship between habitat structure and faunal community organization (*e.g.*, MacArthur and MacArthur 1961). In a study of deciduous forest litter, Uetz (1974) used interstitial space between leaves as a measure of habitat space; curled or bent leaves produce greater interstitial space than flat leaves. Litter depth and habitat space increase as the proportion of curled or bent leaves increases (Uetz 1974, Bell and Sipp 1975).

A number of studies have demonstrated that habitat structure of forest litter influences the composition, abundance and distribution of litter-inhabiting arthropods. Species diversity of cryptostigmatid mites was significantly correlated with the diversity of microhabitats within forest litter (Anderson 1978a, Anderson and Hall 1977). Species richness of litter wandering spiders, as well as their relative abundances, were correlated with litter microhabitat diversity and depth in deciduous forests (Uetz 1975). Variation in leaf shape contributed to litter microhabitat diversity. Stevenson and Dindal (in press) demonstrated that species richness of forest litter spiders is greater in curled litter than in flat litter.

Food resources also are important in affecting the distribution and abundance of litter arthropods. Leaves rich in nitrogen and sugars are consumed more rapidly by fungi and arthropods than litter which is poor in these nutrients (Wallwork 1970, Reynolds 1973). Cryptostigmatid mites feed upon fungi according to fungal distribution in litter subhorizons (Mitchell and Parkinson 1976). Collembola also exhibit selective feeding on fungal species (*e.g.* Dash and Cragg 1972).

The present study attempted to determine the effects of leaf shape and type on community composition of Collembola inhabiting forest litter. Effects of these parameters on the distribution of individual species also were analyzed. The objectives of the study were to test the hypotheses: (1) more springtail species inhabit curled litter than flat litter, (2) densities of individual species are greater in curled litter, and (3) natural litter supports greater numbers of springtail species and individuals than artificial litter.

METHODS

The study was conducted at the Soil Invertebrate Ecology Laboratory at the Lafayette Experimental Station of the SUNY College of Environmental Science and Forestry in Syracuse, New York. A field experiment was conducted in a mixed hardwood stand. Dominant vegetation consisted of red oak (*Quercus rubra* L.) and sugar maple (*Acer saccharum* Marsh.). Understory vegetation was composed of red oak, sugar maple, and black cherry (*Prunus serotina* Ehrh.). Two soil types present on this site were Cazenovia sandy loam and Ontario sandy loam (alfisols, glossoboric hapludalfs). Mull humus characterized the organic subhorizons; forest litter disappeared in about one year primarily due to earthworm activity (Pritchard 1941, Stevenson, pers. obs.).

Litter boxes were used to measure the influence of leaf shape on Collembola community structure since they permitted modification of leaf shape prior to placement in the field (Stevenson and Dindal 1981). Litter boxes (10 cm x 10 cm x 2 cm) were constructed of metal hardware cloth (6.35 mm openings).

Freshly-fallen sugar maple leaves were collected in October 1978 and were separated into 60 batches of 10 leaves each. Similarly, 600 filter paper disks (9.0 cm diameter, Whatman Company) also were separated into 60 batches of 10 disks each. Filter paper disks were chosen as a simulated leaf type to provide a non-nutritive substrate, of which the major variable would be leaf shape.

All leaves and disks were wetted in distilled water until pliable. Flat leaves and disks were made by pressing them flat in a plant press. Curled litter was formed by rolling wet leaves and disks into tubes. Each batch of 10 monotypic units were allowed to dry and then it was placed in a litter box.

Although habitat space was not measured directly, curled litter provided more interstitial space than flat litter, on a qualitative basis, since flat litter formed tight layers and had a more compact appearance than curled litter. This compaction was especially evident in flat filter paper disks since they lacked microrelief, such as venation, which provided interstitial spaces.

A 10 m x 12 m grid with 1 m intervals was formed at the study site. Each litter box was randomly assigned to a position at the intersection of the grid intervals. All boxes were placed on the soil surface by October 1, 1979; subsequent natural litter fall covered the boxes and was left in place. Litter covering the boxes did not enter them and thus did not contribute to leaf treatments or influence leaf structure.

Twelve boxes, three of each litter treatment type, were randomly selected for removal in each month from November 1979 to August 1980 and were individually sealed in plastic bags to prevent loss of arthropods. A previous study (Stevenson and Dindal 1981) revealed that the sample size was adequate to detect differences in arthropod communities between litter treatments. Arthropods in litter boxes were extracted in Tullgren funnels and fixed in a solution of isopropyl alcohol:glycerin:water (80:10:10).

Three-way analyses-of-variance (ANOVA) were performed with leaf type (maple leaves or filter paper disks), leaf shape (curled or flat), and month

(November through August) as independent variables. Dependent variables were Collembola species richness and population densities of *Lepidocyrtus curvicollis* Bourlet and *Sminthurinus elegans* (Fitch). These were the two most abundant species collected. Relative densities of these species within litter treatments were used to measure the effects of leaf type and shape on their microhabitat selection.

RESULTS AND DISCUSSION

A total of 2,147 springtails, representing five families and 16 species, were extracted from litter boxes. A list of the species collected in this study is given in Table 1.

Effect of Leaf Shape. More springtail species were found in curled litter than in flat litter (ANOVA: $F_{1,80} = 5.862$, $P < 0.05$; Table 2). Similarly, greater density of *Lepidocyrtus curvicollis* occurred in the curled litter (ANOVA: $F_{1,80} = 6.197$, $p < 0.05$). The leaf shape effect on Collembola species richness is attributable to differences in the amounts of habitat space in the litter treatments. Flat leaves and filter paper disks formed tight layers with reduced interstitial spaces, especially when wet. More species were able to exploit the greater amounts of habitat space in curled litter, which showed little compaction. Likewise, increased density of *L. curvicollis* in curled litter was due to the large amounts of habitat space. These results confirm the first

Table 1. – List of identified Collembola species extracted from litter boxes. Taxonomic groups follow Snider (1967).

Neanuridae
- *Neanura muscorum* Templeton

Entomobryidae
- *Orchesella albosa* Guthrie
- *Entomobrya assuta* Folsom
- *E. griseoolivata* (Packard)
- *Willowsia platani* (Lubbock)
- *Lepidocyrtus curvicollis* Bourlet
- *L. lanuginosus* (Gmelin)

Isotomidae
- *Folsomia candida* Willem
- *Isotoma notabalis*
- *I. (Desoria) tarvia* Wray
- *I. (Panchaetoma) communa* MacGillivray

Tomoceridae
- *Tomocerus flavascens* (Tullberg)
- *T. minor* (Mills)

Sminthuridae
- *Sminthurinus aureus* (Lubbock)
- *S. elegans* (Fitch)
- *Katannia macgillivrayi* (Banks)

Table 2. – Effect of leaf shape on Collembola species richness and on density of *Lepidocyrtys curvicollis* Bourlet and *Sminthurinus elegans* (Fitch).

	Leaf Shape (number per litter box)	
	Flat	Curled
Species Richness (number of species)	1.72	2.17
Lepidocyrtus curvicollis (number of individuals)	3.53	6.23
Sminthurinus elegans (number of individuals)	6.03	8.02

hypothesis and partially support the second one.

The results also are in accord with previous studies. Uetz (1975, 1976, 1979) found positive correlations between forest litter habitat space and species richness of wandering spiders. Stevenson and Dindal (in press) found greater species richness of litter spiders and increased density of *Enoplognatha ovata* (Clerck) (Theridiidae) in curled litter than in flat litter.

No leaf shape effect was found for density of *Sminthurinus elegans* (ANOVA: $F_{1,80}$ = 1.133, p>0.05; Table 2). This species is considerably smaller than *L. curvicollis* or most of the other species encountered (Maynard 1951, Snider 1967). Differences in habitat space are more important to large litter-inhabiting organisms than to small ones since large interstitial spaces in forest litter are less common than small ones. Spatial requirements of this species may be less than those of the larger species; differences in the spatial scales used in this study may be irrelevant for *S. elegans*.

There is evidence for these ideas in the literature. Cryptostigmatid mites partition litter microhabitats on scale of several millimeters (Anderson 1978a, 1978b), while the appropriate spatial scales of litter-inhabiting spiders are in centimeters (Uetz 1975). Further, searching success of arthropod predators in artificial litter is influenced by litter structure (Martin 1969). The wasp *Trichogramma brasiliaense* Asmead is more efficient at finding prey in large litter units than the smaller mite *Blattisocius tarsilis* (Berlase). The mite is a more successful predator in smaller pieces of litter.

Effect of Leaf Type. More Collembola species were extracted from litter boxes containing maple leaves than from those with filter paper disks (ANOVA: $F_{1,80}$ = 11.801, p<0.001; Table 3). Differences in species number in the leaf types are due, in part, to differences in food resources (*e.g.*, fungi). Although no analyses were conducted on fungal biomass and metabolic activity, filter paper probably supported smaller, less active fungal populations because these disks initially were sterile and had high carbon:nitrogen ratios. The disks contain less than 0.06% ash; nitrogen content is negligible. Fungi must obtain 3 to 4% nitrogen for complete decomposition of substrate car-

bon (Alexander 1977). Thus, filter paper degrades primarily by weathering, not by biological decomposition processes (Dindal and Levitan 1977). If the assumption of smaller fungal populations on filter paper disks is correct, fewer Collembola species may be due to the reduced food resources.

Greater density of both *L. curvicollis* and *S. elegans* occurred in maple leaves than in filter paper disks (ANOVA: *L. curvicollis*, $F_{1,80} = 43.347$, $p<0.001$; *S. elegans*, $F_{1,80} = 11.395$, $p<0.001$; Table 3). Again, reduced food resources on filter paper disks is responsible for smaller densities of these species. These data contrast with those of Gill (1969) who found that replacement of old field litter with non-nutritive dacron resulted in normal densities of microarthropods.

Thus, results of the field experiment support the third hypothesis.

Effect of Month. No predictions were made in the original hypotheses on monthly patterns of springtail community structure or microhabitat selection. Nevertheless, interesting patterns are evident in the data. During summer months, there were significant increases in Collembola species richness (ANOVA: $F_{9,80} = 11.817$, $p<0.001$; Table 4). Likewise, population density of *L. curvicollis* was greater in June and July than in other months (ANOVA: $F_{9,80} = 6.785$, $p<0.001$). Density maxima of *S. elegans*, however, occurred in November and in May to June (ANOVA: $F_{9,80} = 17.461$, $p<0.001$). These population peaks are consistent with seasonal patterns of population growth for these species reported in the literature (Maynard 1951; Snider 1967).

Conclusions. Leaf shape is one variable in a complex association of variables which together constitute the forest litter habitat. Other variables include number and diversity of microhabitats and spatial arrangements of litter units, which may differ for individual species depending on arthropod body size and spatial requirements. Leaf shape is shown to influence directly the number of Collembola species within forest litter and microhabitat selection of one species. Food resources also appear to affect community composition and species distribution. Future research should attempt to assess the degree of influence and exact relationships of variables which affect Collembola communities in forest litter.

Table 3. — Effect of leaf type on Collembola species richness and on density of *Lepidocyrtus curvicollis* Bourlet and *Sminthurinus elegans* (Fitch).

	Leaf Type (number per litter box)	
	Filter Paper Disks	Maple Leaves
Species Richness (number of species)	1.68	2.20
Lepidocyrtus curvicollis (number of individuals)	1.75	8.02
Sminthurinus elegans (number of individuals)	4.65	9.40

Table 4. – Monthly differences in Collembola species richness and in density of *Lepidocyrtus curvicollis* Bourlet and *Sminthurinus elegans* (Fitch). Those means not connected by the same underline are significantly different at the .05 level according to Duncan's Multiple Range Test.

Species Richness
(number of species per litter box)

Feb.	Mar.	Jan.	Apr.	Aug.	Dec.	Nov.	May	Jun.	Jul.
0.83	1.33	1.50	1.58	1.67	1.75	1.83	2.42	2.83	3.83

Lepidocyrtus curvicollis
(number of individuals per litter box)

Feb.	Mar.	Jan.	Apr.	Aug.	Dec.	Nov.	May	Jun.	Jul.
1.08	1.33	1.50	1.83	2.67	2.83	7.17	7.83	8.50	14.42

Sminthurinus elegans
(number of individuals per litter box)

Aug.	Feb.	Mar.	Jul.	Apr.	Jan.	Dec.	May	Jun.	Nov.
0.08	0.67	0.83	0.83	0.92	4.92	7.17	12.17	13.67	29.08

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